

REMARKS

Amendment to Claims

In amending the claims, applicants have taken care to avoid the introduction of new matter and have used language found in the specification, in accordance with MPEP 608.01(o). Support for the subject matter and terminology of the amended claims is as follows.

Support for the claim terminology “upper surface that is substantially stoichiometrically complete in oxygen concentration” may be found at page 5, lines 18-20, and page 7, lines 20-21, and found to be acceptable claim terminology by the Office in the February 5, 2002 Office Action.

Support for the claim terminology “unannealed” is found at page 11, lines 10-11.

Support for the claim terminology “conductive” as used in claim 63 is found at page 20, line 10.

Withdrawal of Final Rejection

Applicants request that the current final rejection be withdrawn because four new references have been cited and this has necessitated further amendment of the claims. Applicants should have the right to enter amendment to the claims in response to the citation of these additional references. Furthermore, applicants are requesting that the current final rejection be withdrawn because the Office did not reply to the amendments filed by applicant in response to the July 24, 2001 Office Action, and the Office's response to such amendments should in fact have been provided to applicants in the February 5, 2002 Office Action in which the Office made all rejections final.

According to MPEP §706.07 “in making the final rejection, all outstanding grounds of rejection of record should be carefully reviewed, and any such grounds relied on in the final rejection should be reiterated. They must be clearly developed to such an extent that applicant may readily judge the advisability of an appeal unless a previous Office action contains a complete statement supporting the rejection.” Applicants expected that if the Office had determined that the amendment to the claims made on November 26, 2001 (in response to the July 24, 2001 Office Action) did not move the prosecution of the application forward, then the Office should have stated this fact in the February 5, 2002 Office Action. Specifically, if the Office determined that the amendment to the claims did not remove Nishioka, et al. as

a relevant reference, then applicants should have been informed of such. Instead, the Office merely stated in the February 5, 2002 Office Action that the arguments were “moot in view of the new grounds of rejections.” This type of response by the Office is not helpful to the applicants nor does it meet the requirements defined in §706.07 of the MPEP.

Clearly applicants should be given the opportunity to respond to a rejection when made final and not be kept in the dark regarding exactly which arguments are moot. Furthermore, the resurfacing of the Nishioka, et al. reference does not meet the requirements of MPEP §706.07 which states that:

“to bring the prosecution to as speedy conclusion as possible and at the same time deal justly by both the applicant and the public, the invention as disclosed and claimed should be thoroughly searched in the first action and the references applied; and in response to this action the applicant should amend with a view to avoiding all the grounds of rejection and objection. **Switching from one subject matter to another in the claims presented by applicant in successive amendments, or from one set of references to another by the examiner in rejecting in successive actions claims of substantially the same subject matter, will alike tend to defeat attaining the goal of reaching a clearly defined issue for an early termination; i.e., either an allowance of the case or a final rejection.**” (emphasis added)

Further, the Office is at this late date making section 112, first paragraph rejections relating to claims 40 and 63 that were amended in the November 26, 2001 in response to the July 24, 2001 Office Action, wherein applicants introduced the claim terminology “the electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ϵ material underneath.” Applicants question why this 112 disclosure rejection was not made in the February 5, 2002 Office Action, and instead, is now being raised for the first time. Applicants should be able to expect some continuity in the examination of the present application, including the opportunity to amend claims and to expect the next subsequent Office Action to address such amended claims on all grounds, rather than conducting continued prosecution with applicants and then a year later raising grounds of rejections of claims that were previously accepted by the Office without any asserted §112 issues.

Rejection of Claims and Traversal Thereof

In the September 30, 2002 Office Action,

claims 40-55 and 61-63 were rejected under 35 U.S.C. §112, first paragraph;

claims 40-55 and 61-62 were rejected under 35 U.S.C. §112, second paragraph;

claims 40-44, 46, 47 and 49-55 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 5,973,911 (Nishioka, et al.);

claims 40, 46 and 50-52 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 6,191,443 (Al-Shareef, et al.);

claims 45, 48, 61-63 were rejected under 35 U.S.C. §103 as being unpatentable over Nishioka, et al in view of U. S. Patent No. 5,807,774 (Desu, et al.) and/or U. S. Patent No. 5,892,254 (Park, et al.); and

claims 40, 41, 45-47, 52 and 55 were rejected under 35 U.S.C. §103 as being unpatentable over U.S. Patent No. 5,783,716 (Baum, et al.).

These rejections are traversed and reconsideration of the patentability of the pending claims is requested in light of the following remarks.

Rejection under 35 U.S.C. § 112, first paragraph

Claims 40-55 and 61-63 were rejected under 35 U.S.C. §112, first paragraph, because according to the Office, “the specification does not reasonably provide enablement for the subject matters that “the electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ϵ material underneath’ and the ‘the ferroelectric or high ϵ material is stoichiometrically satisfied in oxygen content.’”

Regarding the claim terminology “the electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ϵ material underneath,” which was added to the claims in response to the July 24, 2001 Office Action, applicants have herein removed such terminology from independent claims 40 and 63, but with the unequivocal assertion that there is ample support for this claim terminology at page 15, lines 5-8, of the present application. As stated above, if the Office found this claim terminology unacceptable, then the Office should have made this fact known to applicants in the February 5, 2002 Office Action. Nonetheless, to advance prosecution of this application, claims 40 and 63 have been amended as noted..

Applicants have amended the claims to introduce the claim language that the Office found acceptable and expressly set forth at the top of page 3 in the February 5, 2002 Office Action. Specifically, the Office stated:

“the specification supports the subject matter that the ferroelectric oxide or high ϵ oxide material at the upper surface and the vicinity thereof is substantially stoichiometrically complete in oxygen concentration.”

The introduction of this claim language, found to meet all requirement of section 112 by the Office in the February 5, 2002, should obviate this rejection. As such, applicants request that all rejections under 35 U.S.C. §112, first paragraph be withdrawn.

Rejection under 35 U.S.C. §112, second paragraph

Applicants have amended claim 40 thereby obviating this rejection, and as such, this rejection is requested to be withdrawn.

Rejection under 35 U.S.C. §102(e)

Claims 40-44, 46, 47 and 49-55 were rejected under 35 U.S.C. §102(e) as being anticipated by Nishioka, et al. Applicants respectfully submit that Nishioka, et al. does not anticipate the subject matter of applicants' claimed invention.

The Nishioka, et al. reference relates to a ferroelectric thin film capacitor that comprises a top electrode that is annealed in oxygen. As stated in column 3, lines 4, “the oxygen annealing eliminates oxygen holes generated near the interface of the Pt electrode,” and further discussed in column 3, lines 11-12; column 3, lines 21-22; column 3, lines 25-26; column 3, lines 47-48; column 3, lines 51-52; and column 4, lines 44-45, thus providing ample evidence that the Nishioka, et al. invention must include an annealing process to complete the described capacitor.

By contrast, the present invention does not anneal the top electrode – it has been discovered by applicants that if the top electrode is deposited in the presence of oxygen, annealing is not required after deposition is not required.

Anticipation under 35 U.S.C. §102 requires that “each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference.” (See Verdegaal Bros., Inc.

v. Union Oil Co., 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). The cited reference does not meet this standard, and as such, the rejection under 35 U.S.C. §102 should be withdrawn.

Claims 40, 46 and 50-52 were rejected under 35 U.S.C. §102(e) as being anticipated by Al-Shareef, et al. Applicants respectfully submit that Al-Shareef, et al. does not anticipate the subject matter of applicants' claimed invention.

The Al-Shareef, et al. reference describes a capacitor that comprises a dielectric layer comprising Ta₂O₅. By contrast, the presently claimed invention comprises a ferroelectric material, which is used as the dielectric layer between the two electrodes. It is well known to those skilled in the art that all dielectric materials are not considered or exhibit ferroelectric properties. Ta₂O₅ is a dielectric material but there is no evidence that it exhibits ferroelectric properties as shown by the document included in Appendix C that clearly disclose that Ta₂O₅ is a dielectric that is not considered a material that exhibits ferroelectric properties. As such, the Al-Shareef, et al. reference does not disclose, teach or suggest each and every element as set forth in the presently claim invention. Accordingly, applicants respectfully submit that claims 40, 46 and 50-52, as amended herein, are patentably distinguishable over Al-Shareef, et al. Withdrawal of this rejection is requested.

Rejection under 35 U.S.C. §103(a)

In the September 30, 2002 Office Action, claims 45, 48, 61-63 were rejected under 35 U.S.C. §103(a) based on a combination of Nishioka, et al. in view of Desu, et al. and/or Park, et al. Applicants submit that the combination of the cited references does not in any way render applicants' claimed invention *prima facie* obvious.

The present invention relates to a ferroelectric capacitor that provides a ferroelectric layer that is not oxygen-deficient after deposition of the top electrode. Further, the ferroelectric capacitor provides for a top electrode that is formed in the presence of oxygen, thereby eliminating the need for postdeposition annealing of the top electrode.

According to the Office:

“Although Nishioka does not expressly disclose that the ferroelectric material can also be formed of strontium bismuth tantalite [sic]¹ and/or that the top electrode can also be form of Pt oxide, Rh or Rh oxide, one of ordinary skill in the art would readily recognize that strontium bismuth tantalite [sic] is one of the commonly used ferroelectric materials for forming a high dielectric constant capacitor, and that each of Pt oxide, Rh and Rh oxide can be used for the top electrode in a ferroelectric capacitor structure for achieving stable capacitor performance, as evidenced in Desu (see col. 4, lines 15-16 and 20-26) and Park (see col. 1, lines 36-41).”

Applicants vigorously disagree. As stated above, Nishioka, et al. describes a ferroelectric thin film capacitor that comprises a top electrode that is annealed in oxygen. As stated in column 3, lines 4, “the oxygen annealing eliminates oxygen holes generated near the interface of the Pt electrode,” and further discussed in column 3, lines 11-12; column 3, lines 21-22; column 3, lines 25-26; column 3, lines 47-48; column 3, lines 51-52; and at column 4, lines 44-45, thus providing ample evidence that the Nishioka, et al invention must include an annealing process to complete the described capacitor. Likewise, Desu, et al. describes a capacitor comprising electrodes that are annealed in the presence of oxygen, as described in the abstract, and column 4, lines 7-8 and 35-36. Thus, even if the two references were combinable, which they are not, the combination does not teach or suggest each and every claimed element of the present invention. Specifically, the proposed combination does not in any way disclose, teach or suggest the fabrication of a top electrode that does not require annealing.

Park, et al. describes a capacitor that prevents diffusion of oxygen from dielectric layers by providing a barrier layer comprising refractory metal and grain boundary filling material. The barrier layer can reduce and preferably prevent diffusion of oxygen therethrough, and thereby reduce the leakage current and oxidation of the integrated circuit capacitor. The barrier layer, which is the gist of the Park, et al. disclosure, is deposited beneath the lower electrode. The lower electrode is fabricated of a Pt metal that preferably includes the grain boundary filling material, which is included to supply oxygen to the interface between the lower electrode and high dielectric layer. However, there is no mention in this Park, et al. reference regarding a method to prevent diffusion of oxygen from the dielectric layer during the deposition of the top electrode. Thus, when combining the teaching of Nishioka, et al. and Park, et al. one skilled in the art would recognize the shortcomings of Park, et al. and go in the direction of Nishioka, et al. by annealing the top electrode in a oxygen atmosphere. It should be recognized that one skilled in the art would not go in the direction of applicants because there is no suggestion in either of the cited references to deposit the top electrode in an oxygen rich atmosphere thereby eliminating the need for a final annealing process.

¹ There is no such composition as “strontium bismuth tantalite;” the Office is believed to be intending to refer to “strontium bismuth tantalite.”

Clearly neither reference teaches or suggests going in the direction of applicants' claimed invention. Of course, if one had applicants' present application in hand, as the Office does, it would be easy to use impermissible hindsight and go in the direction of applicants' claimed invention. However, the Office is not allowed to use the knowledge learned from the present application when attempting to prove obviousness to defeat patentability.

Applicants point out that obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination and suggesting the desirability of the combination. Applicants respectfully submit that the Office's statement that "the claimed invention would be obvious to one having ordinary skill in the art" is not sufficient by itself to establish *prima facie* obviousness. According to the Board in *Ex parte Obukowicz*, 27 U.S.P.Q. 2d 1063, 1065 (B.P.A.I. 1992):

"In proceedings before the Patent and Trademark Office, the examiner bears the burden of establishing a *prima facie* case of obviousness based upon the prior art. The examiner can satisfy this burden only by showing some **objective** (emphasis added) teaching in the prior art or that knowledge generally available to one of ordinary skill in the art would lead that individual to combine the relevant teaching of the references."

See also *Ex parte Humphreys*, 24 USPQ 2D 1255, 1262 (B.P.A.I. 1992) where the Board addressed this very issue and determined the Office was wrong in rejecting the claims for obviousness because the examiner's rejection was not **specific** as to how one of ordinary skill in the art would have found it obvious to combine the references. Furthermore, they noted that the examiner had not explained with any **specificity what areas of the references would suggest the combination**.

Applicant submits that the Office has not provided objective or specific teachings or suggestions in the cited prior art to motivate one skilled in the art to combine said references. Thus, the Office is merely reinterpreting the prior art in light of the applicants' disclosure.

Moreover, what is the asserted motivation put forth in either reference to form a top electrode in an oxygen rich atmosphere to insure that the upper surface of the ferroelectric layer is substantially stoichiometrically complete in oxygen concentration? As discussed above, Nishioka, et al. and Desu, et al. teach the importance of annealing the top electrode in oxygen, and Park, et al. does not recognize the

problem of oxygen diffusion during the deposition of the top electrode, and as such, none of the references provides any suggestion to go in the direction of applicants' claimed invention.

Further, applicants submit that the Office has failed to give weight to the advantages and benefits of the present invention in considering the "invention as a whole" and that the Office has cited references that do not disclose or teach such advantages or benefits. Applicants note that for some metals used in the deposition of electrodes the use of postdeposition annealing may be acceptable because the top electrodes will allow oxygen to diffuse therethrough to replenish the oxygen content of the underlying dielectric layer. However, this method is not acceptable when using preferred materials such as Ir and IrO₂ because they are not good oxygen diffusion barriers. Thus, applicants recognized this shortcoming and the presently claimed invention allows for the deposition of the preferred top electrode material by depositing in an oxygen atmosphere, which replenishes the oxygen content to the upper surface of the ferroelectric oxide layer. Obviously, the cited references do not recognize the benefits of the present invention.

In light of the above discussion and the fact that the Office has not met its burden of establishing a *prima facie* case of obviousness, applicants request that the rejection of claims 45, 48, 61-63, on §103 grounds, be withdrawn.

Claims 40, 41, 45-47, 52 and 55 were rejected under 35 U.S.C. §103 as being unpatentable over Baum, et al. Applicants submit that the cited reference does not in any way render applicants' claimed invention *prima facie* obvious.

According to the Office:

"[I]t would have been obvious to one of ordinary skill in the art at the time the invention was made to make the microelectronic device of Baum with the capacitor dielectric layer being formed of strontium bismuth tantalite [sic], so that a microelectronic device with desired capacitor performance would be obtained, per the further teachings of Baum. And it is noted that, oxygen deficiency in such an underlying capacitor dielectric layer including its surface region would be inherently prevented from happening, due to the incorporated-oxygen environment during the CVD process in Baum."

Applicants agree that Baum, et al. describes the deposition of platinum from a liquid platinum source material used in a chemical vapor deposition process. The source material may include the presence of an oxidizing gas or a reducing gas depending on the intended use. Baum, et al. also teaches that the

described liquid platinum source material may be used for deposition of an electrode on a dielectric layer for use in a capacitor. However, the cited reference is completely silent on postdeposition annealing of the formed platinum electrode or whether the upper surface and vicinity thereof of the ferroelectric oxide film material is substantially stoichiometrically complete in oxygen concentration. The only guidance in this respect is Nishioka, et al., which teaches that when Pt electrodes are fabricated, one has to anneal the electrode in oxygen.

The Office has not provided any evidence to show that Baum, et al. teaches or suggests that the deposited platinum electrode did not require further annealing in oxidizing conditions to compensate for loss of oxygen in the ferroelectric oxide layer. Further, there is nothing in the prior art that teaches that the upper surface and vicinity thereof of the ferroelectric oxide film material is substantially stoichiometrically complete in oxygen concentration, and the Office cannot conjure these elements up by relying on something that is not disclosed. There is nothing in the Baum et al. reference that would imply or from which could be inferred that the oxygen content in the upper surface of the ferroelectric oxide layer is stoichiometrically complete in oxygen.

The discussion in Baum et al. regarding the surface of the complex oxide capacitor film as not being deteriorated in an adverse manner in respect of film stoichiometry, capacitance, dielectric constant, capacitance per area, and device performance does not address whether postdeposition annealing is required or not required. Again, the only guidance is Nishioka, et al., which teaches that when Pt electrodes are fabricated, one has to anneal the electrode in oxygen. Heretofore it was unknown that the deposition of a platinum electrode in the presence of an oxidizing agent would not require postdeposition annealing. Hence, obviousness cannot be predicated on what is not known at the time an invention is made. *In re Rijckaert*, 28 USPQ2d 1955 (Fed. Cir. 1993). Therefore, how could a skilled artisan make any modification to arrive at an invention that possesses such heretofore unknown characteristic? Serendipity is not a valid basis for asserting obviousness.

As the Court stated in *Interconnect Planning Corp v. Feil*, 227 USPQ 543 (Fed. Cir. 1985) “The invention must be viewed not with the blueprint drawn by the inventor, but **in the state of the art that existed at the time.**” (emphasis added) As stated above, the state of the art existing at the time of the invention was characterized by further annealing processes after the deposition of the electrode as evidenced by the teachings of Nishioka, et al. and Desu, et al. The applicants have surprisingly discovered, however, that a postdeposition annealing process is not required and that the upper surface

and vicinity thereof of the ferroelectric oxide film material is substantially stoichiometrically complete in oxygen concentration when depositing the top electrode in the presence of oxygen.

In conclusion and in light of the above discussion, applicants contend that the Office has not met its burden of establishing a *prima facie* case of obviousness. Accordingly, applicants respectfully request that the rejection of claims 40, 41, 45-47, 52 and 55 on the basis of obviousness, be withdrawn.

CONCLUSION

Applicants have satisfied the requirements for patentability. All pending claims are free of the art and fully comply with the requirements of 35 U.S.C. §112. It therefore is requested that Examiner Hu reconsider the patentability of claims 40-55 and 61-63, in light of the distinguishing remarks herein, and withdraw all rejections, thereby placing the application in condition for allowance. Notice of the same is earnestly solicited. In the event that any issues remain, Examiner Hu is requested to contact the undersigned attorney at (919) 419-9350 to resolve same.

Respectfully submitted,



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Appendix A –Version with Markings to Show Changes Made

In the Claims

Please amend claims 40-55 and 61-63 as follows:

40. (Thrice amended) A microelectronic device structure including [a] an unannealed top electrode layer positioned on a top surface of a ferroelectric oxide [or high ϵ oxide] film material, wherein said top surface and vicinity thereof of the ferroelectric oxide [or high ϵ oxide] film material is substantially stoichiometrically complete in oxygen concentration [stoichiometrically satisfied in oxygen content, including the top surface region of the ferroelectric oxide or high ϵ oxide film material, and wherein the top electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ϵ material underneath].
41. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric [or high ϵ] film comprises an oxide perovskite or layered structure perovskite.
42. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric [or high ϵ] film comprises a material selected from the group consisting of lead zirconium titanate, barium and/or strontium titanates, and strontium bismuth tantalates.
43. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric [or high ϵ] film comprises a lead zirconium titanate material.
44. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric [or high ϵ] film comprises a barium and/or strontium titanate material.
45. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric [or high ϵ] film comprises a strontium bismuth tantalate material.
46. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises a material selected from Pt, Pt oxides, Ir, Ir oxides, Pd, Pd oxides, Rh, Rh oxides, and compatible mixtures and alloys of the foregoing.
47. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises a Pt material.

48. (Amended) A microelectronic device structure according to claim 40, wherein said top unannealed electrode layer comprises a Pt oxide material.
49. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer is formed of Ir.
50. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises an Ir oxide material.
51. (Amended) A microelectronic device structure according to claim 40, wherein the unannealed top electrode layer is formed of Ir or IrO₂.
52. (Amended) A microelectronic device structure according to claim 40, wherein the unannealed top electrode is formed in an oxygen-enriched environment.
53. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode is formed of a metallic non-oxide material by sputtering in the presence of oxygen.
54. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode is formed of a noble metal that is formed by evaporation of a noble metal source material in the presence of oxygen.
55. (Amended) A microelectronic device structure according to claim 40, wherein the unannealed top electrode layer is formed of a noble metal by a chemical vapor deposition process that incorporates oxygen.
61. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises Rh.
62. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises a Rh oxide material.
63. (Twice amended) A ferroelectric or high ϵ capacitor comprising:

a bottom electrode layer formed of a conductive material [selected from the group consisting of Ir, Ir oxide, Rh, Rh oxides, and compatible mixtures and alloys thereof];

a thin film of a ferroelectric [or high ϵ] material positioned over the bottom electrode, wherein the thin film of a ferroelectric oxide material has a top surface that is substantially stoichiometrically complete in oxygen concentration, wherein said ferroelectric oxide material comprises a material selected from the group consisting of lead zirconium titanate, barium and/or strontium titanates, and strontium bismuth tantalates, [, wherein the material is stoichiometrically satisfied in oxygen content, including the surface region of the material adjacent to the top electrode layer]; and

an unannealed top electrode layer positioned on the top surface of the thin film of ferroelectric [or high ϵ] oxide material, which is formed of a material selected from the group consisting of Ir, Ir oxide, Rh, Rh oxides and compatible mixtures and alloys thereof [, wherein the top electrode layer does not contain oxygen content abstracted from the thin film of ferroelectric or high ϵ material underneath].

Appendix B

All Pending Claims

40. (Thrice amended) A microelectronic device structure including an unannealed top electrode layer positioned on a top surface of a ferroelectric oxide film material, wherein said top surface and vicinity thereof of the ferroelectric oxide film material is substantially stoichiometrically complete in oxygen concentration.
41. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric film comprises an oxide perovskite or layered structure perovskite.
42. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric film comprises a material selected from the group consisting of lead zirconium titanate, barium and/or strontium titanates, and strontium bismuth tantalates.
43. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric film comprises a lead zirconium titanate material.
44. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric film comprises a barium and/or strontium titanate material.
45. (Amended) A microelectronic device structure according to claim 40, wherein said ferroelectric film comprises a strontium bismuth tantalate material.
46. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises a material selected from Pt, Pt oxides, Ir, Ir oxides, Pd, Pd oxides, Rh, Rh oxides, and compatible mixtures and alloys of the foregoing.
47. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises a Pt material.
48. (Amended) A microelectronic device structure according to claim 40, wherein said top unannealed electrode layer comprises a Pt oxide material.

49. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer is formed of Ir.
50. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises an Ir oxide material.
51. (Amended) A microelectronic device structure according to claim 40, wherein the unannealed top electrode layer is formed of Ir or IrO₂.
52. (Amended) A microelectronic device structure according to claim 40, wherein the unannealed top electrode is formed in an oxygen-enriched environment.
53. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode is formed of a metallic non-oxide material by sputtering in the presence of oxygen.
54. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode is formed of a noble metal that is formed by evaporation of a noble metal source material in the presence of oxygen.
55. (Amended) A microelectronic device structure according to claim 40, wherein the unannealed top electrode layer is formed of a noble metal by a chemical vapor deposition process that incorporates oxygen.
61. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises Rh.
62. (Amended) A microelectronic device structure according to claim 40, wherein said unannealed top electrode layer comprises a Rh oxide material.
63. (Twice amended) A ferroelectric or high ϵ capacitor comprising:

a bottom electrode layer formed of a conductive material;

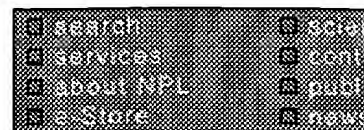
a thin film of a ferroelectric oxide material positioned over the bottom electrode, wherein the thin film of ferroelectric oxide material has a top surface that is substantially stoichiometrically complete in oxygen concentration, wherein said ferroelectric oxide material comprises a material selected from the group consisting of lead zirconium titanate, barium and/or strontium titanates, and strontium bismuth tantalates; and

an unannealed top electrode layer positioned on the top surface of the thin film of ferroelectric oxide material, which is formed of a material selected from the group consisting of Ir, Ir oxide, Rh, Rh oxides and compatible mixtures and alloys thereof.

APPENDIX C



Sensors & Functional Materials: Material Systems



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Dielectric Applications

- Tantalum Pentoxide Ta_2O_5 capacitors
- Tantalum Oxide Ta_2O_5 capacitor dielectric
- Alumina Al_2O_3 capacitor dielectric
- Zirconia ZrO_2 capacitor dielectric
- Silicon Nitride Si_3N_4 capacitor dielectric
- Titanium oxide TiO_2 capacitor dielectric

Piezoelectric and ferroelectric applications

- Lithium Niobate $LiNbO_3$ SAW
- PZT Lead Zirconate Titanate $Pb(Zr(x)Ti(1-x))O_3$ FE memory cells, PFM, DRAM, MEMS - microactuators, sensors, ultrasonic motors, pyroelectric IR detector array, integrated piezo devices, electro-optic modulators, micropumps or micromixers
- PLZT Lead Lanthanum Zirconate Titanate $PbLa(Zr(1-x)Ti(x))O_3$ FeRAM
- Strontium Niobate $Sr_2Nb_2O_7$ FRAM
- Lanthanum Titanate $La_2Ti_2O_7$ FRAM
- PLT Lead Lanthanum Titanate $Pb(1-x)La(x)Ti(1-x/4)O_3$, pyroelectric IR detector array
- Strontium Tantalate Niobate $Sr_2Ta(1-x)Nb(x)O_7$ FRAM, relaxors

- Barium Titanate BaTiO_3 microactuators, FRAM
- BST Barium Strontium Titanate $\text{Ba}(x)\text{Sr}(1-x)\text{TiO}_3$ capacitors for DRAM, electronically scanning antennas, tunable filters, capacitor, discrete variable capacitors for microwave integrated circuits, phase shifter circuit, microwave and rf components for communications
- Strontium Titanate SrTiO_3 stacked capacitors for DRAM, tunable microwave devices
- SBT Strontium Bismuth Tantalate $\text{SrBi}_2\text{Ta}_2\text{O}_9$ DRAM, non-volatile memory
- EAPs thick film – P(VDF-TrFE), polyurethane, silicone – robotics, active damping, vibration control/isolation, ultrasonic transducers, manipulation
- Lithium Tantalate LiTaO_3 SAW
- BTO Bismuth Titanate $\text{Bi}_4\text{Ti}_3\text{O}_{12}$ FRAM
- Bismuth Titanium Tantalate $\text{Bi}_3\text{TiTaO}_9$
- Barium Bismuth Titanate $\text{Ba}_2\text{Bi}_4\text{Ti}_5\text{O}_{18}$ non-volatile FRAM
- Antimony Sulpho-Iodide SbSI pyroelectric, pyro-optic applications
- BLT Bismuth Lanthanum Titanate $\text{Bi}(4-x)\text{La}(x)\text{TiO}_{12}$ FeRAM
- SBBT Strontium Barium Bismuth Tantalate (Sr,Ba) $\text{Bi}_2\text{Ta}_2\text{O}_9$ FRAM
- PMN Lead Magnesium Niobate $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3$ relaxor

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